PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference PCT2109AP071jdc	**FOR FURTHER ACTION**	See Form PCT/IPEA/416
International application No. PCT/EP2004/007386	International filing date *(day/month/year)* 06.07.2004	Priority date *(day/month/year)* 07.07.2003
International Patent Classification (IPC) or national classification and IPC H01S5/183		
Applicant AVALON PHOTONICS AG et al.		

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 8 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
   a. ☒ *sent to the applicant and to the International Bureau)* a total of 10 sheets, as follows:
      ☒ sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
      ☒ sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.
   b. ☐ *(sent to the International Bureau only)* a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or tables related thereto, in computer readable form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).

4. This report contains indications relating to the following items:

☒	Box No. I	Basis of the opinion
☐	Box No. II	Priority
☐	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
☐	Box No. IV	Lack of unity of invention
☒	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
☐	Box No. VI	Certain documents cited
☐	Box No. VII	Certain defects in the international application
☐	Box No. VIII	Certain observations on the international application

Date of submission of the demand	Date of completion of this report
09.05.2005	07.10.2005
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized Officer Laenen, R Telephone No. +49 89 2399-6031

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/EP2004/007386

Box No. I Basis of the report

1. With regard to the **language**, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.

   ☐ This report is based on translations from the original language into the following language , which is the language of a translation furnished for the purposes of:
   - ☐ international search (under Rules 12.3 and 23.1(b))
   - ☐ publication of the international application (under Rule 12.4)
   - ☐ international preliminary examination (under Rules 55.2 and/or 55.3)

2. With regard to the **elements*** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

Description, Pages

2, 4-7, 9-23	as originally filed
1, 1a, 3, 8	received on 09.05.2005 with letter of 09.05.2005

Claims, Numbers

1-29	received on 09.05.2005 with letter of 09.05.2005

Drawings, Sheets

1/9-9/9	as originally filed

☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing

3. ☐ The amendments have resulted in the cancellation of:
   - ☐ the description, pages
   - ☐ the claims, Nos.
   - ☐ the drawings, sheets/figs
   - ☐ the sequence listing *(specify)*:
   - ☐ any table(s) related to sequence listing *(specify)*:

4. ☒ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).
   - ☒ the description, pages 3,8
   - ☒ the claims, Nos. 1,23
   - ☐ the drawings, sheets/figs
   - ☐ the sequence listing *(specify)*:
   - ☐ any table(s) related to sequence listing *(specify)*:

* *If item 4 applies, some or all of these sheets may be marked "superseded."*

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	10,11,14,15,17-19,21,22,24,27-29
	No:	Claims	1-9,12,13,16,20,23,25,26
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-29
Industrial applicability (IA)	Yes:	Claims	1-29
	No:	Claims	

2. Citations and explanations (Rule 70.7):

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. The following documents (D1-D5) are referred to in this communication; the numbering will be adhered to in the rest of the procedure:

D1: EP-A-0 772 266

D2: US-A-5 256 596

D3: SHINADA S ET AL: "Micro-aperture surface emitting laser for near field optical data storage" LASERS AND ELECTRO-OPTICS, 1999. CLEO/PACIFIC RIM '99. THE PACIFIC RIM CONFERENCE ON SEOUL, SOUTH KOREA 30 AUG.-3 SEPT. 1999, PISCATAWAY, NJ, USA,IEEE, US, 30 August 1999 (1999-08-30), pages 618-619, XP010364559 ISBN: 0-7803-5661-6

D4: EP-A-1 276 188

D5: NISHIYAMA N ET AL: "MULTI-OXIDE LAYER STRUCTURE FOR SINGLE-MODE OPERATION IN VERTICAL-CAVITY SURFACE-EMITTING LASERS" IEEE PHOTONICS TECHNOLOGY LETTERS, IEEE INC. NEW YORK, US, vol. 12, no. 6, June 2000 (2000-06), pages 606-609, XP000951817 ISSN: 1041-1135

2. Amendments filed with letter dated 09.05.2005 do not meet the requirements of Art. 34(2)(b) PCT.

Claims 1 and 23 comprise in addition to originally filed claims 1,23 the restriction of "so as to stabilize the fundamental lateral mode". Originally disclosed in the description of the application as filed is however only the restriction, that in the case of the "**first characteristic lateral size is greater than the second characteristic lateral size**" the fundamental mode with a **reduced gain for high order modes is preferentially supported**. As the latter features are missing in claims 1 and 23, the subject-matter of these claims extends beyond the disclosure as originally filed contrary to Art. 34(2)(b) PCT. Consequently the examination is based on originally filed claims 1,23 and claims 2-22,24-29 as filed with letter dated 09.05.2005.

3. Clarity objections.
Claims 1,2,4-9,15,16,19,20,23-29 lack clarity in the sense of Art. 6 PCT.
3.1 Claims 1 and 23 comprise the restriction of "so as to stabilize the fundamental lateral mode". This wording is however not allowable as only the result to be achieved is defined in said claims instead of stating device features (for example the relation of diameters of apertures) as would have been appropriate in this case (see International Preliminary Examination Guidelines 5.35).
3.2 In claims 27-29 characteristic **dimensions** are mentioned although in claims 23-26, to which these claims refer back, only a characteristic **lateral size** is defined. Therefore the "dimensions" are interpreted in terms of "lateral sizes".
3.3 Claims 1,2,4-9,15,16,19,23,25,26: The meaning of a "characteristic lateral size" is not clear as non-circular shaped apertures are also within the scope of the claims (see claim 21) which need at least two parameters to be defined in respect to their lateral size. To allow for an examination of said claims, the objected term is interpreted in terms of a "circular area defined by a characteristic diameter" (see Fig. 1e and claims 19,20 as well as the fact, that in all claims only **one** characteristic size is given and this is a clear hint towards a circular shape).
3.4 Claims 20,24,25 refer back to themselves leaving the claimed subject-matter unclear.
3.5 Claims 6 and 7 comprise the term "in the range of 6(4) µm". As it is however well known that a range has a starting and an end point, the scope of protection sought by said claims is completely unclear. In order to allow for examination of the subject-matter of said claims, said objected term is interpreted in terms of "in the range of 4 to 7 µm" (see claim 8).

4. The subject-matter of claims 1-9,12,13,16,19,20 is not new in the sense of Article 33 (2) PCT.

Document D1 is considered to represent the closest prior art.

4.1 D1 discloses a VCSEL 30 (Fig. 3) comprising
(I) a substrate with lower electrical contact 45 and second mirror stack 31 (Fig. 3; col.

5, l. 2-7; although not explicitly stated in D1 it is clear that a substrate must be present in order to be able to grow the layers cited in D1; electrical contacts are known to be made from metals);
(ii) a laser active region 32 (Fig. 3; col. 3, l. 30);
(iii) a first mirror stack 37 formed of alternating high and low index of refraction AlGaAs layers (Fig. 3; col. 3, l. 55-59; it is clear that these layers are doped in order to allow for a current flow); the first mirror stack comprising
(a) a first plurality of doped layers 39 having alternately low and high index of refraction (Fig. 2; col. 3, l. 31-54; note the layers below aperture layer 42),
and two circular apertures,
(b) first circular aperture with diameter of about 23.5 µm is formed above said first plurality of layers by implanting 42 part of layers 39 (Figs. 2,3; col. 4, l. 27-30; it is well known that implantation results in electrical insulation and absorbance of laser radiation and implantation is a standard workshop alternative to for example oxidation of a layer to build an aperture; the diameter of about 23.5 µm is calculated from col. 3, l. 16-18 and col. 4, l. 56 - col. 5, l. 1 and Fig. 3);
© a second circular aperture is formed above said first plurality of layers by oxidation 38 part of layers 39 resulting in an aperture with a diameter smaller than the diameter of the mesa and diameter of the first aperture (Fig. 3; it is clear from the oxidation process that the oxidized Al-oxid is insulating and substantially non-transparent while the non-oxidized part is well-known to be transparent for the laser wavelength and conductive); and
(d) a second plurality of AlGaAs layers 37 forming a mesa with diameter of approximately 19.5 µm being smaller as the diameter of the first aperture of 23.5 µm and the diameter of the non-etched part of the plurality of mirror layers (see point 3.5 above; Fig. 3; see discussion in point (b) above), the difference of about 4 µm in diameters of the aperture and the mesa being adapted to generate increased optical losses of the resonator made up by mirrors 31,37 with respect to higher order modes for the laser wavelength compared to the losses by the aperture alone (col. 3, l. 16-18 and col. 4, l. 50 - col. 5, l. 1) which implicitly equals support of fundamental mode emission considering also the circular shapes of the apertures); and
(e) a radiation output window 44 above said first reflector formed by the circular aperture within electrical contact 43, the aperture having a smaller diameter as the mesa or the aperture layer 42 (Fig. 3; col. 5, l. 2-5; electrical contacts are known to be

made from metals; from the diameters defined in D1 it is clear that all apertures are circular; see point 3.3 above).

Therefore, the subject-matter of claims 1-9,12,13,16,19,20 is not new in the sense of Article 33 (2) PCT.

4.2 According to the wording of claim 1 the subject-matter of claim 1 is also known from D2 as D2 discloses a GaAs substrate 12 with a lower p-DBR mirror stack 14, an active zone 16 and an upper n-DBR mirror stack 18 with a buried Be Implant 27 leaving an aperture above part of the mirror layers and a mesa 25 with smaller diameter (Figs. 1,2; col. 2, l. 28 - col. 4, l. 12; an implant is the standard workshop alternative to oxidation of a layer in order to realize an aperture and implantation results in electrical insulation of the implanted region as well as absorbance of laser light) with the difference of the diameters of the mesa and the aperture being adapted for lowest order mode lasing (col. 3, l. 37-62; this equals fundamental mode lasing).

5. The subject-matter of claims 23,25,26 is not new in the sense of Article 33 (2) PCT.

Document D1 is considered to represent the closest prior art.

D1 discloses a method of forming a VCSEL comprising the steps of
selecting together with a laser wavelength appropriate semiconductor materials for first and second DBR mirror (the use of AlGaAs DBR clearly indicates a laser wavelength around 800 nm as well known to the skilled person);
determining an aperture diameter equal to the minimum acceptable diameter of the aperture formed by oxidation of AlGaAs layers (col. 3, l. 1-41);
choosing the diameter of the mesa depending on the size of the aperture and the operation of the laser in the basic mode (col. 4, l. 50 - col. 5, l. 1);
forming the active region and the output window according to the dimensions given from the diameter of the aperture of about 23.5 µm and the mesa of 19.5 µm (see points 3.3 and 4.1 above for references).

Therefore, the subject-matter of claims 23,25,26 is not new in the sense of Article 33 (2)

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6. Dependent claims 10,11,14,15,17,18,21,22,24,27-29 do not appear to contain any additional features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT with respect to inventive step, the reasons being as follows:

Any number of doped layers in a DBR is obvious to grow depending on the desired reflectivity, contacting above the active layer is an obvious alternative to contacting the substrate, an aperture smaller than the mesa is known form D2 (Fig. 3), phase-matching layers above the upper DBR are known from D3 (Fig. 1), non-circular shaped apertures or windows are known from D4 for polarization control (Fig. 5; par. 20,21,33-37). Calculations of the optical and electrical field distribution within VCSEL are well-known and therefore obvious for the skilled person to optimize the design of a VCSEL in respect to laser threshold, polarization control and fundamental mode operation (see D3 and D5 and point 3.1 above). From these calculations automatically margins for characteristic diameters are inferred and therefore obvious.